

# **City of Baltimore**

## **Low Level Sewershed Study**

### **Alternatives Analysis and Recommendations Report**

October 30, 2009



## Alternatives Analysis and Recommendations Report

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### EXECUTIVE SUMMARY

As part of Baltimore City Project No. 1029, Hazen and Sawyer, PC, Hatch Mott MacDonald and PHR&A have developed a calibrated hydraulic model of the Low Level sewershed within the City of Baltimore. The calibrated model was used to simulate a series of design storm rainfall events to identify possible sanitary sewer overflow (SSO) locations. This report outlines the recommendations for the elimination of SSOs from the Low Level collection system due to wet weather inflow and infiltration up to the 20-year, 24 hour design storm event.

A Consent Decree between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment was executed in April, 2002 and issued in May, 2002. As stipulated on page 22 of the Consent Decree, the City of Baltimore shall identify all sewer system components that cannot manage peak flows during a full range of design storms. The City shall then identify the required improvements to ensure long term capacity with no SSOs for the full range of design storms. These design storms include: the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours) and the 1-, 2-, 5-, 10-, 15-, and 20-year, 24 hour design storms.

Per the Consent Decree and the City of Baltimore, the sewer system improvements considered to assure adequate capacity shall include, but not be limited to, replacement of malfunctioning pumping station equipment, installation of pumping station back-up equipment, reduction of inflow and infiltration, installation of larger replacement sewers or relief sewers, sewer pressurization (gravity system pressurized by head), and storage (both inline and offline). In evaluating sewer system improvements, emphasis was placed on cost effectiveness, constructability and optimization of the existing sewer system. Information from the closed circuit television inspections, flow metering results, and smoke/dye testing were utilized in selecting the areas for inflow and infiltration removal.

From the technical program guidelines provided by the City, a comprehensive inflow and infiltration removal program (cured in place pipe lining of all public and private sewers and manhole rehabilitation/replacement) is estimated to remove up to 80% of rainfall dependant inflow and infiltration and dry weather infiltration. Since it is proposed to only rehabilitate the public side of the collection system, the hydraulic model was modified to only account for a 40% reduction in rainfall dependant inflow and infiltration and dry weather infiltration in the locations selected for inflow and infiltration reduction. This inflow and infiltration removal approach was evaluated alongside other improvement options such as upsizing pipes or adding relief sewers, adding storage, pump station upgrades and sewer pressurization to identify the most cost effective, constructible recommendations.

Estimated construction costs were based on standard unit prices provided by the City in 2008 dollars. These standard costs are fully loaded costs and include items such as mobilization, maintenance of traffic, paving restoration, bypass pumping and miscellaneous (non-sanitary) utility work. These unit costs are also escalated by an additional 42% to accommodate engineering design, construction management, construction inspection, administration, post-award engineering services and contingencies. A 7 percent annual inflation rate is used to project costs for years beyond 2008.

The Lower Gwynn's Falls area was identified as the most flood prone area within Low Level and predicted to have the largest SSO volumes from the simulated design storms. For the 5-year design storm and larger, system improvements were needed in other parts of the Low Level collection system. These general areas include Western Gwynn's Falls, along the Eastern Interceptor and in the Locust Point area. Three improvement options were evaluated to eliminate SSOs in the Lower Gwynn's Falls area and two improvement options were investigated in the peripheral areas. The two principal options



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generally came down to a primarily CIPP lining option and a primarily storage option. The third option in the Lower Gwynn's Falls area involves evaluating a lowering of the Eastern Avenue Pump Station (EAPS) wet well pump operation level. This option, subject to system and pump operating limitations, would lower the EAPS wet well pump operation level by two feet. This lowering would allow the EAPS to better buffer against abrupt inflows experienced during large storm events. Improvements associated with these different options are described in the following paragraphs for the various design storms.

One necessary system improvement regardless of what improvement option is evaluated is cleaning the entire Low Level sewershed system of accumulated sediment and debris. Because of the current operation at the EAPS, low velocities are experienced throughout large portions of the Low Level sewershed. These low velocities cause sediment and debris to settle out of the flow and build-up within the pipe network. Cleaning the collection system, particularly the Eastern and Western Interceptors, will improve the flow carrying capacity of the collection system and reduce SSO occurrences and total SSO volumes.

For the 2-year design storm, a variety of improvements in Low Level are needed to eliminate localized system bottlenecks and to reduce I&I. Option 2 for the Gwynn's Falls area is recommended for this storm event. This option involves upsizing the Western Interceptor for approximately 1.3 miles and CIPP rehabilitation in the vicinity. Additionally, five subcatchments in the Locust Point area would be subject to CIPP rehabilitation in order to reduce wet weather flows. Other minor peripheral improvements within Low Level are also required. The combined improvement cost to convey the two-year storm is estimated to be \$28.9 million in 2008 dollars. The average cost to eliminate each gallon of estimated overflow is \$8.35 in 2008 dollars.

For the 5-year storm it is recommended that Option 1 is implemented for the Gwynn's Falls Area. This option largely entails storage in the Upper and Lower reaches of Gwynn's Falls. Three other main flooding areas arise during this storm event; the Eastern Interceptor south of Patterson Park, Locust Point, and Western Gwynn's Falls. For the Eastern Interceptor it is recommended to CIPP several subcatchments along with the upsizing of hydraulic restrictions; Western Gwynn's it is recommended to construct a 0.3 million gallon storage tank; and for Locust Point it is recommended to install a 0.4 million gallon storage tank. The combined improvement cost to convey the five-year storm is estimated to be \$59.9 million in 2008 dollars. The average cost to eliminate each gallon of estimated overflow is \$9.52 in 2008 dollars with the incremental improvements for this storm event costing \$10.96 per additional gallon eliminated.

The improvements for the 10-, 15-, and 20-year storm are very similar in that Option 2 is recommended for implementation in the Gwynn's Falls Area. The size of the tank in the Upper and Lower regions of Gwynn's Falls will increase as the storm event becomes larger in volume. For the Eastern Interceptor and Locust Point Areas, storage along with supplemented upsizing of hydraulic restrictions is recommended for both regions for the 10-, 15-, and 20-year events. The recommendation for the Western Gwynn's Falls region varies depending upon the storm event. For the 10- and 15-year storm event upsizing and CIPP is the recommended option; for the 20-year storm event, storage is the recommended option. The 10-, 15-, and 20-year storm would cost a total of \$93.8 million, \$109.4 million, and \$129.5 million in 2008 dollars, respectively. The cost in 2008 dollars per gallon of SSO removed is for the 10-, 15-, and 20-year events are \$10.40, \$10.32, and \$10.44, respectively.



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### 1.0 PROJECT DESCRIPTION

#### 1.1 Project Location

The Low Level Sewershed encompasses approximately 13.3 square miles within the City of Baltimore, as depicted in Figure 1-1. The sewershed encompasses the central business district of the City and is highly developed with an estimated population of 375,000. The Low Level Sewershed consists of approximately 300 miles of gravity sewer system, nearly 10,000 manholes and structures and three primary pumping stations. Of the entire Low Level collection system, about 90 miles of pipe (between 10-inches and 84-inches in diameter), 3,400 manholes and structures and all three of the primary pumping stations are included in the Low Level hydraulic model.

**Figure 1-1: Low Level Sewershed Project Area**



The Low Level sewershed is located in the downtown and adjacent harbor areas of the City of Baltimore. The sewershed includes dense residential areas, heavily industrial areas and the downtown central business district. The diverse land uses and significant industrial areas make the Low Level sewershed unique in comparison to the City's other sewersheds. The sewershed borders each of the other sewersheds within the City and discharges its sewage to the Outfall Interceptor for conveyance to the Back River Wastewater Treatment Plant.





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### 1.2 Sub-Sewersheds

During the creation of the Low Level hydraulic model, the sewershed was divided into 681 sub-sewersheds. These sub-sewersheds were utilized in the hydraulic model and represent the unit used for identify portions of the sewershed that would be rehabilitated using cured-in-place-pipe methods. The Low Level sub-sewersheds were based upon Sanitary Sewer Areas (SSAs) provided as a starting point by the City. These SSAs were subdivided as necessary to end with the final sub-sewersheds entered into the hydraulic model.

### 1.3 Consent Decree Requirements and Guidelines

A Consent Decree (CD) was agreed upon between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment, executed in April, 2002 and issued May, 2002. As stipulated on page 22 of the CD, the City of Baltimore shall identify all components that cannot manage peak flows during a full range of design storms. The City shall then identify the required improvements necessary to ensure long term capacity with no SSOs for the full range of design storms. These design storms include: the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours) and the 1-, 2-, 5-, 10-, 15-, and 20-year, 24 hour design storms.

As specified in the CD, the future conditions model shall be used to determine the requirements necessary to convey all the flows without an SSO occurrence. The future conditions model, as outlined in the *Baseline Analysis and Capacity Assessment Report*, dated February 2009, projects the population to year 2025 and includes a 10% increase in average daily infiltration to account for future pipe deterioration.

### 1.4 Alternative Selection Process

In evaluating possible upgrades to the Low Level collection system, the first event considered is the 2-year design storm. The improvements identified in the following sections are compiled to convey each progressive storm event with no SSO occurrences. As larger design storms are analyzed, greater numbers of SSOs occur with larger SSO volumes requiring more comprehensive system improvements to eliminate the SSO occurrences.

Per the CD and as defined in the BaSES Manual, the following general categories of improvements were investigated:

- Replacement of malfunctioning pump station equipment
- Installation of pump backup equipment
- Increase in pumping capacity
- I/I reduction
- Installation of larger pipes or relief pipes
- Installation of storage facilities

In reviewing the feasibility of the evaluated alternatives, emphasis was placed on cost effectiveness, constructability and optimization of existing sewer facilities. The following improvements were evaluated for the Low Level Sewershed depending on the specific characteristics of each individual SSO location:



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- I&I reduction using CIPP
- Pipe upsizing to remove hydraulic bottlenecks in the system
- Parallel sewers, including re-activation of existing abandoned sewers
- Storage facilities
- Pump station upgrades where a pump station is causing a hydraulic bottleneck

Where I&I reduction was considered most applicable, information from the closed circuit television (CCTV) inspections, flow metering results, and smoke/dye testing were utilized in selecting the areas for I&I removal. As per the BaSES Manual, a comprehensive I&I removal program (CIPP lining) of all public and private sewers and manhole rehabilitation/replacement is estimated to eliminate up to 80% of rainfall dependant inflow and infiltration (RDII) and all dry weather infiltration. It is proposed to only rehabilitate the public side of the collection system, therefore the hydraulic model was modified to only account for a 40% reduction in RDII in the locations selected for I&I reduction.

An operational change that may help eliminate SSOs in the Low Level Sewershed, is changing the wet well operating levels at the EAPS. Reducing the wet well levels will reduce the backwater effects from the EAPS and provide some additional buffering from large wet weather inflows during large storm events. In addition, this operational change should increase velocities entering the EAPS and reduce sediment build-up in the system largely caused by very low velocities. It is assumed that this operational change at the EAPS will be implemented through a control system programming change since the EAPS is currently being upgraded to enable automated pump operation. These potential benefits will need to be weighed against potential drawbacks to this approach (e.g., reduced NPSHA and other impacts to pump design criteria) to determine if this is a feasible operational change. For the purposes of this alternatives analysis, a water level decrease of 2 feet at EAPS was assumed as part of Option 2.

Three improvement options were evaluated for the 2-year through 20-year design storms. These options generally focus on the Gwynn's Falls area due to the predominance of SSO activity in that area.

- **Option 1:** Storage in the Upper and Lower Gwynn's Falls areas in addition to CIPP lining to reduce I&I and pipe size increases to fix hydraulic restriction points.
- **Option 2:** Upsizing of the West Interceptor and CIPP lining in the Gwynn's Falls area assuming a 2-foot drop in the EAPS wet well levels. This option also includes additional CIPP lining of select subcatchments and pipe size increases to fix specific hydraulic restriction points.
- **Option 3:** Upsizing of the West Interceptor and CIPP lining in the Gwynn's Falls area assuming the EAPS wet well levels remain unchanged. This option also includes additional CIPP lining of select subcatchments and pipe size increases to fix specific hydraulic restriction points.

These three general approaches were evaluated for each of the 2-year through 20-year design storms. The specific improvements for these options were adjusted accordingly to eliminate SSOs for each design storm.

### 1.5 Assumptions

The following assumptions were made when performing hydraulic model simulations of the improvement alternatives:





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- Year 2025 estimated average daily flow rates with diurnal peaking factors and a 10% increase of daily infiltration from baseline conditions.
- The NRCS-NOAA rainfall distribution is used for all of the design storms. This synthetic rainfall distribution has high rainfall intensity at the middle of the storm that is typically not seen in natural storms.
- Use of the InfoWorks SWMM Runoff routine in conjunction with the median capture coefficient (R-value) calculated from the I&I evaluation. Winter storms may generate higher R-values than summer storms due to a higher groundwater table resulting in more rainfall entering the sanitary sewer system. The groundwater table during the summer months is often lower than during the winter due to increased evaporation and a greater groundwater withdrawal by vegetation. As a result even though summer storms are often more intense than winter storms, summer storms may have less I&I entering the sanitary sewer system. With only a single year of rainfall and flow monitoring data, it is unclear whether the averaging of the summer and winter R values introduces a factor of safety by allowing higher than normal R values during the more severe summer storms. However, it should be noted that during the City's 12-month flow monitoring program, the observed precipitation was greater than the average annual precipitation for the Baltimore region.
- The evaluation of alternatives does not take into account other system wide improvements that are required based on the condition and criticality ranking of the sewage system components, which may decrease the severity of RDII.
- No restrictions were placed on the maximum pumping rate from the EAPS to the Outfall Interceptor. There are likely limitations on this discharge rate due to downstream hydraulic constraints and the capacity constraints of the Back River Wastewater Treatment Plant. These potential limitations likely will not allow unrestricted pumping from the EAPS and these impacts should be investigated using the City-wide hydraulic model.
- Per Section 8.2.1.5.2 of the BaSES Manual, comprehensive sewer rehabilitation will result in a 40% reduction in RDII. However, the percent reduction that is actually achieved is highly dependent on local conditions and other factors that will vary throughout the sewershed.
- Sediment removal from the system will be performed as a base maintenance activity and should be an ongoing maintenance activity to keep the collection system free of restrictive sediment.

The assumptions outlined above may result in the recommended improvements being oversized or undersized compared to real world conditions.

Table 1-1 summarizes the impact of system cleaning on SSOs for the various design storms. The costs for this cleaning will be included in the summary of 2-year design storm improvements. It is also recommended that every sewer pipe that is cleaned be re-inspected using CCTV to assess the condition of the pipes for any features that may not have been readily visible during the initial CCTV inspections.



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**Table 1-1: System Cleaning Impact on SSOs**

Design Storm	SSOs Before Cleaning		SSOs After Cleaning		
	Number of MHs	SSO Volume (MG)	Number of MHs	SSO Volume (MG)	SSO Volume Reduction (MG)
2-Year Storm	42	3.48	28	2.88	0.60
5-Year Storm	135	6.43	75	4.97	1.46
10-Year Storm	235	9.05	169	7.37	1.68
15-Year Storm	293	10.70	212	8.67	2.03
20-Year Storm	352	12.28	318	9.94	2.34

Standard unit costs for sewer point repairs, sewer lining, sewer replacement, and manhole rehabilitation/replacement were provided by the City in 2008 dollars. These costs are fully loaded costs and include items such as mobilization, maintenance of traffic, paving restoration, bypass pumping and miscellaneous (non-sanitary) utility work. For costs not provided by the City (cleaning, storage, and pumping stations for example) recent projects within the City and surrounding areas were reviewed to assist in estimating the most probable fully loaded cost of construction. An additional 42% is added to the total fully loaded construction costs to accommodate engineering design, construction management/inspection, administration, post-award engineering services and contingencies. A 7% annual inflation rate is assumed to project future costs in the summary tables at the end of this report. The costs presented for alternatives for each of the design storms throughout the report are presented in a 2008 cost-basis.



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### 2.0 2-YEAR IMPROVEMENTS

The 2-year design storm is anticipated to result in approximately 3.5 million gallons in SSOs throughout the Low Level Sewershed. The following improvements were identified to mitigate the SSO flows for the 2-year design storm. The recommended improvements are shown on Map 2.1.

#### 2.1 General Improvements (Apply to All Options)

The following collection system improvements are common to all three options for the 2-year design storm. These improvements remove significant hydraulic restrictions in the collection system and rehabilitate pipes and manholes in subcatchments that are significantly impacted by I&I.

- System Cleaning: To restore lost capacity to the collection system, the system will be cleaned of all sediment and debris. It is estimated that system cleaning will reduce the 2-year design storm SSO volumes by about 600,000 gallons. The cleaning is anticipated to remove approximately 4,700 tons of sediment and debris from the collection system.
- Seal Manholes in the Gwynn's Falls Floodplain: The floodplain adjacent to Gwynn's Falls and in other low-lying areas often experiences both SSOs and flooding from high river levels during storm events. It is proposed that 77 manholes be sealed to prevent overflow of sewage from collection system as well as to prevent direct inflow of river water into the collection system during large storm events.
- Upsize 10-Inch Pipe to 15-Inch Pipe: To eliminate a hydraulic restriction along the railroad near the intersection of Laurey and Severn Street, approximately 20 feet of 10-inch pipe is proposed to be upsized to 15-inch pipe.
- Upsize 8-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction along Benson Avenue near DeSoto Road, approximately 130 feet of 8-inch pipe is proposed to be upsized to 18-inch pipe to match the surrounding pipes. Three manholes would be replaced as part of this improvement.
- Construct 10-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction in the vicinity of the Eastern Interceptor between Ellwood Street and Lindwood Street, a 10-inch parallel sewer will be installed. Seven manholes will be installed as part of this improvement.
- CIPP All Sewer Pipes in 10 Subcatchments: Five subcatchments in the Gwynn's Falls area and five subcatchments in the Locust Point area would be subjected to a system-wide CIPP lining and manhole rehabilitation program to reduce RDII flows from the subcatchments.

#### 2.2 Option 1 – Storage Plus Extensive CIPP

This option includes installation of two storage tanks in the Lower Gwynn's Falls area in addition to the improvements included in Section 2.1.

- Construct Two Storage Facilities: A 2.8 million gallon offline underground storage tank would be installed in the Lower Gwynn's Falls area near the southwest quadrant of the intersection of Interstate 95 and the Baltimore-Washington Parkway. Another 500,000 gallon offline underground storage tank would be required in the Upper Gwynn's Falls area located near the Carroll Golf Course.



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### 2.3 Option 2 – CIPP, West Interceptor Upsizing and Lower EAPS Water Level

During the 2-year design storm, lower EAPS wet well levels have an impact on the length of Western Interceptor that must be upsized to manage the wet weather flows. A comparison between Option 2 and Option 3 shows that reducing the wet well pump operation level at the EAPS is estimated to save approximately \$13 million dollars. The following improvements for Option 2 are required to eliminate SSOs for the 2-year design storm.

- Reduce the Wet Well Level in the Eastern Avenue Pump Station by 2 Feet: The EAPS typically operates with high wet well pump operation levels. These high wet well levels cause backwater effects in the collection system resulting in low flow velocities, increased sedimentation and surcharged flow conditions. Hydraulic model simulation results show that fewer collection system improvements to eliminate SSOs in Low Level when the pump operation levels at the EAPS are reduced. However, the impact of this wet well level change will need to be evaluated for impacts to pump hydraulics.
- Upsize the West Interceptor: Approximately 2,800 feet of 33-inch and 36-inch pipe would be upsized to 54-inches and approximately 3,400 feet of 36-inch pipe would be upsized to 60-inches to provide additional capacity in the Western Interceptor. This improvement includes replacing 28 manholes along the interceptor.
- CIPP All Sewer Pipes in 16 Subcatchments: Sixteen additional subcatchments in the Gwynn's Falls area would have system-wide CIPP lining and manhole rehabilitation performed to reduce RDII flows from the subcatchments.

### 2.4 Option 3 – CIPP with West Interceptor Upsizing

If the EAPS wet well pump operation levels are left unchanged, additional pipes will need upsized and new areas will require rehabilitation of pipes and manholes to eliminate SSOs compared to Option 2. The improvements included in for Option 3 to eliminate SSOs for the 2-year design storm are:

- Upsize the West Interceptor: Approximately 2,800 feet of 33-inch and 36-inch pipe would be upsized to 54-inches, approximately 4,800 feet of 36-inch and 51-inch pipe would be upsized to 60-inches, and approximately 3,600 feet of 51-inch pipe would be upsized to 72-inch pipe to provide additional capacity in the Western Interceptor. This improvement includes replacing 51 manholes along the interceptor.
- CIPP All Sewer Pipes in 20 Subcatchments: Sixteen additional subcatchments in the Gwynn's Falls area and four additional subcatchments in the Locust Point area would have system-wide CIPP lining and manhole rehabilitation performed to reduce RDII flows from the subcatchments.

### 2.5 Summary of Estimated Costs

Table 2-1 summarizes the estimated costs for the three options to mitigate SSOs during the 2-year design storm. Option 2 is shown in green as having the lowest total cost and being the recommended option. The recommended improvements are also shown on Map 2.1.



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**Table 2-1: Summary of Estimated Costs for 2-Year Design Storm Improvements**

Improvement	Unit	Unit Cost	Option 1		Option 2		Option 3	
			Quantity	Total Cost	Quantity	Total Cost	Quantity	Total Cost
CIPP								
MH Rehab	Each	\$3,719	196	\$728,924	374	\$1,390,906	374	\$1,390,906
<8-inches	LF	\$45	16,270	\$732,140	27,789	\$1,250,501	27,789	\$1,373,703
9-12 inches	LF	\$64	3,274	\$209,549	4,902	\$313,734	4,902	\$398,607
13-18 inches	LF	\$87	3,893	\$338,686	5,276	\$458,999	5,276	\$458,999
19-24 inches	LF	\$124	1,579	\$195,835	8,271	\$1,025,576	8,271	\$1,074,071
25-30 inches	LF	\$169	2,952	\$498,896	6,756	\$1,141,766	6,756	\$1,294,363
31-36 inches	LF	\$186	1,076	\$200,138	1,503	\$279,535	1,503	\$279,535
49-54 inches	LF	\$495	0	\$0	55	\$27,172	55	\$27,172
Replacement								
New MH	Each	\$3,719	7	\$26,033	27	\$100,413	40	\$148,760
9-12 inches	LF	\$495	810	\$400,950	810	\$400,950	810	\$400,950
13-18 inches	LF	\$585	150	\$87,750	150	\$87,750	150	\$87,750
49-54 inches	LF	\$1,800	0	\$0	2,793	\$5,027,400	2,793	\$5,027,400
>54 inches	LF	\$1,890	0	\$0	3,393	\$6,412,770	8,424	\$15,921,360
Clean System	Tons	\$500	4,656	\$2,327,778	4,656	\$2,327,778	4,656	\$2,327,778
Seal MH	Each	\$1,240	77	\$95,454	77	\$95,454	77	\$95,454
Storage	Gallons	\$6	2,809,977	\$16,859,862	0	\$0	0	\$0
EAPS WW Drop		\$25,000	0	\$0	1	\$25,000	0	\$0
Construction Costs				\$22,701,996		\$20,365,703		\$30,306,808
Non-Construction Costs				\$9,534,838		\$8,553,595		\$12,728,859
2008 TOTAL COSTS				\$32,236,834		\$28,919,299		\$43,035,667





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### 3.0 5-YEAR IMPROVEMENTS

The 5-year design storm is anticipated to result in approximately 6.5 million gallons in SSOs throughout Low Level Sewershed. The SSOs are more widespread in the Gwynn's Falls area, in the area south of Patterson Park as well as in the Locust Point Area compared to the 2-year design storm. However, overall flooding within Low Level is still localized into problematic areas rather than generalized across the sewershed. Starting with the 5-year design storm, three additional localized areas will have distinct improvement options evaluated. These localized areas include the Western Gwynn's Falls Area, the Locust Point Area and an area along the Eastern Interceptor. These three areas are in addition to the Lower Gwynn's Falls area that is included for all of the design storms.

A summary of the overall results for the 5-year design storm include:

- Lower Gwynn's Falls - Storage becomes the most cost effective option for eliminating SSOs. Lowering the wet well pump operation levels at the EAPS potentially provides millions of dollars in savings when comparing the two CIPP/Pipe Upsize options.
- Western Gwynn's Falls - Storage is a dramatically more cost effective than a combination of CIPP/Pipe Upsize (50% cheaper).
- Eastern Interceptor – The storage and the CIPP/Pipe Upsize options are very close in total cost.
- Locust Point - Storage is a dramatically more cost effective option than a combination of CIPP/Pipe Upsize (just under 50% cheaper).

The following improvements are in addition to those identified for the 2-year design storm except as noted. The recommended improvements are shown on Map 3.1.

#### 3.1 General Improvements (Apply to All Options)

These general improvements eliminate pipe capacity restrictions and reduce I&I in highly impacted subcatchments throughout the Low Level sewershed. The general improvements for the 5-year design storm include:

- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction along Elamont Street, Ottawa Avenue, Parkman Avenue, Georgetown Road, Forrest Hill Avenue and Herkimer Street, approximately 1,800 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe to match the surrounding pipes. In the northwest quadrant of Low Level two sections of pipe would be upsized: approximately 20 feet of 8-inch pipe near Font Hill Avenue would be upsized to 10-inch pipe and approximately 250 feet of 8-inch pipe near Little Stafford Street would be upsized to 10-inch pipe. Near the Eastern Interceptor along Toone Street approximately 525 feet of 8-inch pipe would be upsized to 10-inch pipe.
- Upsize 12-Inch Pipe to 15-Inch Pipe: To eliminate a hydraulic restriction near the intersection of South Monroe Street and Washington Boulevard, approximately 340 feet of 12-inch pipe is proposed to be upsized to 15-inch pipe to match the surrounding pipes.
- Upsize 10-Inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction near the intersection of South Monroe Street and Wicomico Street, approximately 650 feet of 10-inch pipe is proposed to be upsized to 12-inch pipe to match the surrounding pipes.
- Upsize 18-Inch Pipe to 33-Inch Pipe: To eliminate a hydraulic restriction near the intersection of Scott Street and Ostend Street, approximately 70 feet of 18-inch pipe is proposed to be upsized to 33-inch pipe to match the surrounding pipes.



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- Upsize 6-Inch Pipe to 8-Inch Pipe: To eliminate a hydraulic restriction near the intersection of Lombard Street and Curley Street, approximately 270 feet of 6-inch pipe is proposed to be upsized to 8-inch pipe to match the surrounding pipes.
- CIPP All Sewer Pipes in 13 Subcatchments: Eight subcatchments in the Gwynn's Falls area, four subcatchments in the north-central portion of Low Level and one subcatchment in the eastern portion of Low Level would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.

### 3.2 Option 1 – Storage Plus CIPP and Upsize

The Lower and Upper Gwynn's Falls area storage tanks continue to increase in size to accommodate the increased flows resulting from the 5-year event. The additional specific improvements from Option 1 required to eliminate SSOs for the 5-year storm include:

- Construct Two Storage Facilities: A 3.3 million gallon offline underground storage tank would be required in the Lower Gwynn's Falls area in the southwest quadrant of the intersection of Interstate 95 and the Baltimore-Washington Parkway. This tank would be in place of the 2.9 million gallon tank identified for the 2-year design storm. A 600,000 gallon offline underground storage tank would also be required in the Upper Gwynn's Falls area near the western corner of the Carroll Park Golf Course. This tank would be in place of the 500,000 gallon tank identified for the 2-year design storm.

### 3.3 Option 2 – CIPP, West Interceptor Upsizing and Lower EAPS Water Level

The major part of this Option is upsizing significant portions of the Western Interceptor. Although the decreased wet well pump operation levels at the EAPS help minimize the impacts, a significant portion of the interceptor downstream of where it diverges from Gwynn's Falls will need to be upsized. The specific improvements from Option 2 that are required to eliminate SSOs for the 5-year storm include:

- Upsize the Western Interceptor:
  - Approximately 2,250 feet of 36-inch and 33-inch pipe would be upsized to 54-inches to provide additional capacity in the Western Interceptor between where the interceptor crosses I-95 and Bush Street.
  - Approximately 3,325 feet of 36-inch pipe would be upsized to 60-inches to provide additional capacity in the Western Interceptor between Bush Street and Alluvion Street.
  - Approximately 7,600 feet of 60-inch and 66-inch pipe would be upsized to 72-inches to provide additional capacity in the Western Interceptor between Alluvion Street and the intersection of West Pratt Street and Light Street.
- CIPP All Sewer Pipes in One Subcatchment: One more subcatchment in the Gwynn's Falls area would have CIPP lining and manhole rehabilitation performed to reduce RDII flows flow from the subcatchments.

### 3.4 Option 3 – CIPP with West Interceptor Upsizing

With no change in wet well level at the EAPS, the Western Interceptor needs substantial replacement to manage the flows from the Gwynn's Falls area of the sewershed without SSOs. As before significantly higher capital improvement costs are required when the EAPS wet well level is left



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unchanged. The additional improvements identified from Option 3 that are required to eliminate SSOs for the 5-year storm include:

- Upsize the West Interceptor:
  - Approximately 1,390 feet of 30-inch and 33-inch pipe would be upsized to 36-inches to provide additional capacity in the Western Interceptor between Washington Boulevard and where the interceptor crosses I-95.
  - Approximately 5,560 feet of 33-inch and 36-inch pipe would be upsized to 60-inches to provide additional capacity in the Western Interceptor between where the interceptor crosses I-95 and the intersection of Warner Street and Alluvion Street. This upsizing would be in lieu of some of the upsizing identified as part of the 2-year design storm improvements.
  - Approximately 5,660 feet of 42-inch, 51-inch, and 60-inch pipe would be upsized to 72-inches and approximately 1,900 feet of 66-inch pipe would be upsized to 84-inches to provide additional capacity in the Western Interceptor between the intersection of Warner Street and Alluvian Street and the intersection of West Pratt Street and Light Street.
- CIPP All Sewer Pipes in One Subcatchment: One more subcatchment in the Gwynn's Falls area would have CIPP lining and manhole rehabilitation performed to reduce RDII flows from the subcatchments.

### 3.5 East Interceptor South of Patterson Park

During the 5-year design storm, the hydraulic model predicts significant flooding along the Eastern Interceptor in the vicinity of the intersection of Boston Street and O'Donnell Street. The model also shows that due to hydraulic restrictions in this area, SSOs will occur north of Patterson Park. According to the City's complaint database, this area north of Patterson Park has been subject to numerous complaints helping confirm the model results. The following two alternatives were investigated to alleviate the SSOs in the Eastern Interceptor area.

#### Option A: Storage and Minimal Pipe Upsizing:

- Upsize 27-Inch Pipe to 36-Inch Pipe: To eliminate a hydraulic restriction along Glover Street, approximately 125 feet of 27-inch pipe is proposed to be upsized to 36-inch pipe.
- Construct a Storage Facility: To contain the SSOs for the 5-year design storm, a 1.1 million gallon off line storage tank would be required in the Eastern Interceptor area. The underground storage tank would be located along the harbor near the intersection of Lakewood Avenue and Boston Street.

#### Option B: Extensive CIPP and Extensive Pipe Upsizing:

- Upsize 27-Inch Pipe to 36-Inch Pipe: To eliminate a hydraulic restriction along Hudson Street and Glover Street, approximately 1,025 feet of 27-inch pipe is proposed to be upsized to 36-inch pipe.
- Upsize 15-Inch and 18-Inch Pipe to 21-Inch Pipe: To eliminate a hydraulic restriction along Lakewood Avenue, approximately 1,000 feet of 18-inch pipe is proposed to be upsized to a 21-inch pipe
- Upsize 36-Inch Pipe to 48-Inch Pipe: To eliminate a hydraulic restriction along the Eastern Interceptor along Boston Street, approximately 1,700 feet of 36-Inch pipe is proposed to be upsized to 48-Inch Pipe.



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- CIPP All Sewer Pipes in 4 Subcatchments. Four additional subcatchments in the Eastern Interceptor area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.

### 3.6 Locust Point Interceptor

During the 5-year design storm, the hydraulic model predicts significant flooding in the upper portions of the Locust Point interceptor in the industrial areas along the harbor between Key Highway and Nicholson Street. The following two alternatives were investigated to alleviate the SSOs in this area.

#### Option A: Storage

- Construct a Storage Facility: A 400,000 gallon offline underground storage tank would be required in the upper Locust Point interceptor area. The underground storage tank would be located near the intersection of Key Highway and Fort Avenue.

#### Option B: Extensive CIPP

- CIPP All Sewer Pipes in 13 Subcatchments. Thirteen additional subcatchments in the Locust Point area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.

### 3.7 Western Gwynn's Falls

During the 5-year design storm, the hydraulic model predicts significant flooding along the western side of Gwynn's Falls in the area upstream from the second siphon near Interstate 95. The following two alternatives were investigated to alleviate the SSOs in this area.

#### Option A: Storage and Upsizing

- Construct 18-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 18-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement.
- Upsize 8-Inch to 10-Inch: To eliminate a hydraulic restriction in the vicinity of the intersection of Washington Boulevard and Somersworth Street approximately 190 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe.
- Construct a Storage Facility: A 300,000 gallon offline underground storage tank would be required in the western side of Gwynn's Falls. The offline storage tank would be located near the intersection of Maisel Street and Carroll Street.

#### Option B: Extensive CIPP and Upsizing

- Construct 18-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 18-inch parallel sewer will be installed. This improvement includes installing six new manholes along this parallel sewer.
- CIPP All Sewer Pipes in 10 Subcatchments. Ten additional subcatchments in the Western Gwynn's Falls area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.



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### 3.8 Summary of Estimated Costs

Table 3-1 and Table 3-2 summarize the estimated costs for the improvement options for the 5-year design storm. Option 1 is shown in green as having the lowest total cost and being the recommended option. The recommended improvements are shown on Map 3.1.





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**Table 3-1: Summary of Estimated Costs for 5-Year Design Storm Improvements – Primary**

Improvement	Unit	Unit Cost	Option 1		Option 2		Option 3	
			Quantity	Total Cost	Quantity	Total Cost	Quantity	Total Cost
CIPP								
MH Rehab	Each	\$3,719	316	\$1,175,204	399	\$1,483,881	399	\$1,483,881
<8-inches	LF	\$45	30,189	\$1,358,486	33,105	\$1,489,720	33,105	\$1,489,720
9-12 inches	LF	\$64	4,628	\$296,219	6,126	\$392,082	6,126	\$392,082
13-18 inches	LF	\$87	3,554	\$309,166	3,554	\$309,166	3,554	\$309,166
19-24 inches	LF	\$124	674	\$83,526	3,795	\$470,571	3,795	\$470,571
25-30 inches	LF	\$169	2,410	\$407,307	5,072	\$857,218	5,072	\$857,218
31-36 inches	LF	\$186	1,076	\$200,138	1,503	\$279,535	1,503	\$279,535
49-54 inches	LF	\$495	0	\$0	55	\$27,172	55	\$27,172
Replacement								
New MH	Each	\$3,719	34	\$126,446	76	\$282,644	76	\$282,644
<8-inches	LF	\$270	268	\$72,360	268	\$72,360	268	\$72,360
9-12 inches	LF	\$495	4,014	\$1,986,930	4,014	\$1,986,930	4,014	\$1,986,930
13-18 inches	LF	\$585	468	\$273,780	468	\$273,780	468	\$273,780
31-36 inches	LF	\$1,530	69	\$105,570	69	\$105,570	1,452	\$2,221,560
49-54 inches	LF	\$1,800	0	\$0	2,246	\$4,042,800	0	\$0
>54 inches	LF	\$1,890	0	\$0	10,863	\$20,531,070	13,108	\$24,774,120
Clean System	Tons	\$500	4,656	\$2,327,778	4,656	\$2,327,778	4,656	\$2,327,778
Seal MH	Each	\$1,240	77	\$95,480	77	\$95,480	77	\$95,480
Storage	Gallons	\$6	3,823,580	\$22,941,478	0	\$0	0	\$0
EAPS WW Drop		\$25,000	0	\$0	1	\$25,000	0	\$0
Construction Costs				\$31,759,868		\$35,052,758		\$37,343,998
Non-Construction Costs				\$13,339,144		\$14,722,158		\$15,684,479
2008 TOTAL COSTS				\$45,099,012		\$49,774,916		\$53,028,477

**Table 3-2: Summary of Estimated Costs for 5-Year Design Storm Improvements - Localized Areas**

Item	Unit	Unit Cost	Western Gwynn's Falls Area				Eastern Interceptor Area				Locust Point Area			
			Storage		CIPP and Upsize		Storage		CIPP and Upsize		Storage		CIPP and Upsize	
			Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost
CIPP														
MH Rehab	Each	\$3,719	0	\$0	210	\$780,990	0	\$0	31	\$115,289	0	\$0	256	\$952,064
<8-inches	LF	\$45	0	\$0	22,203	\$999,124	0	\$0	2,681	\$120,660	0	\$0	23,290	\$1,048,031
9-12 inches	LF	\$64	0	\$0	1,450	\$92,827	0	\$0	1,427	\$91,355	0	\$0	6,534	\$418,199
13-18 inches	LF	\$87	0	\$0	3,996	\$347,646	0	\$0	357	\$31,054	0	\$0	992	\$86,270
19-24 inches	LF	\$124	0	\$0	4,642	\$575,639	0	\$0	0	\$0	0	\$0	1,712	\$212,290
25-30 inches	LF	\$169	0	\$0	494	\$83,466	0	\$0	0	\$0	0	\$0	3,195	\$539,934
31-36 inches	LF	\$186	0	\$0	0	\$0	0	\$0	151	\$28,042	0	\$0	0	\$0
Replacement														
New MH	Each	\$3,719	13	\$48,347	8	\$29,752	2	\$7,438	18	\$66,942	0	\$0	0	\$0
9-12 inches	LF	\$495	726	\$359,370	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0
13-18 inches	LF	\$585	752	\$439,920	752	\$439,920	0	\$0	0	\$0	0	\$0	0	\$0
19-24 inches	LF	\$1,080	0	\$0	0	\$0	0	\$0	996	\$1,075,680	0	\$0	0	\$0
31-36 inches	LF	\$1,530	0	\$0	0	\$0	120	\$183,600	1,020	\$1,560,600	0	\$0	0	\$0
43-48-inches	LF	\$1,710	0	\$0	0	\$0	0	\$0	1,659	\$2,836,890	0	\$0	0	\$0
Storage	Gallons	\$6	227,481	\$1,364,883	0	\$0	1,025,297	\$6,151,783	0	\$0	380,112	\$2,280,674	0	\$0
Construction Costs				\$2,212,520		\$3,349,363		\$6,342,821		\$5,926,512		\$2,280,674		\$3,256,787
Non-Construction Costs				\$929,259		\$1,406,732		\$2,663,985		\$2,489,135		\$957,883		\$1,367,850
2008 TOTAL COSTS				\$3,141,779		\$4,756,096		\$9,006,806		\$8,415,647		\$3,238,557		\$4,624,637



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### 4.0 10-YEAR IMPROVEMENTS

The 10-year design storm is anticipated to result in approximately 9.1 million gallons of SSOs throughout the Low Level Sewershed. The SSOs resulting from this design storm are generally grouped in the Gwynn's Falls area, the Eastern Interceptor area south of Patterson Park, the Locust Point area, Western Gwynn's Falls and in the north-central portion of the City just to the east of Interstate 83

In the Gwynn's Falls area, storage located in upper and lower Gwynn's Falls (Option 1) becomes the preferred alternative for eliminating the SSOs. A combination of CIPP and pipe upsizing (Options 2 and 3) become unfeasible options for several reasons including: significantly higher costs of implementation, practical concerns of upsizing the Western Interceptor for such a long distance and the likelihood of pumping restrictions being placed on the EAPS due to downstream capacity constraints.

The Eastern Interceptor area south of Patterson Park and the Western Gwynn's Falls area could potentially be resolved by using a combination of CIPP/pipe upsizing or by installing storage with minimal pipe upsizing. In both cases the capital costs for these two approaches are quite close with no clear advantage to either alternative. The estimated costs for Western Gwynn's Falls improvements show that a combination of CIPP/pipe upsizing is approximately 10% lower cost than a primarily storage option. The CIPP/pipe upsizing vs. storage costs for the Eastern Interceptor area south of Patterson Park are very close with the storage option having about 2% lower estimated costs.

In the Locust Point area, the same methodology presented for in the 5-year design storm improvements was used for the 10-year design storm. A comparison of storage vs. CIPP/pipe upsizing reveals that storage is a far more cost effective option (nearly 50% lower capital costs) and it is recommended as a result.

Similarly in the north-central portion of the City, three main options were identified, but based on the characteristics of the area and the impacts of each of these methods, only one was carried forward. The SSOs in this area could be addressed by upsizing the local interceptor, adding a storage tank or performing extensive CIPP lining. The area is densely developed, eliminating a storage tank, and extensive CIPP lining may have a limited impact given that the R-value for this area was not excessive, indicating that rainfall impacts on sewer flows are not the main culprit in the SSOs for this area. Upsizing the local interceptor results in a long-term investment in the area and will provide additional capacity to manage the increased flows during longer return period storm events.

The following improvements are in addition to those required for the 2-year and 5-year design storms to mitigate the SSOs predicted during the 10-year storm except where noted. The recommended improvements are shown on Map 4.1.

#### 4.1 General Improvements (Apply to All Options)

Beginning with the 10-year design storm, the SSO impacts of these large design storms become more widespread throughout the Low Level Sewershed. A large portion of these improvements are to address localized undersized pipes that result in upstream SSOs.

- **Seal Manholes:** Six additional manholes will need to be sealed for the 10-year design storm. Four of these manholes are located in close proximity to the Eastern Interceptor with the other two manholes located in the Gwynn's Falls area.



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- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction along South Catherine Street near its intersection with Hollins Road, approximately 170 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe to provide additional conveyance capacity.
- Upsize 15-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction along Washington Boulevard near its crossing of Interstate 95, approximately 1,900 feet of 15-inch pipe is proposed to be upsized to 18-inch pipe to provide additional conveyance capacity.
- Upsize 24-Inch Pipe to 27-Inch Pipe: To eliminate a hydraulic restriction in the North Central Area of the City, the approximately 1,900 feet of 24-inch piping along North Front Street, South Front Street and Lombard Street between the intersections of North Front Street/Low Street and Lombard Street/Albermarle Street is proposed to be upsized to 27-inch pipe to provide additional conveyance capacity for the north-central area of the City. This improvement eliminates the need for subcatchment rehabilitation in the area identified as part of the 5-year improvements.
- CIPP All Sewer Pipes in 9 Subcatchments: Nine additional subcatchments in the Gwynn's Falls area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.

### 4.2 Option 1 – Storage in Upper and Lower Gwynn's Falls

Two storage tanks in the Gwynn's Falls area provide the needed volume to store the excess wet weather flows during the 10-year design storm. The following additional improvements are recommended for the 10-year storm:

- Construct Two Storage Facilities: A 4.1 million gallon storage tank would be required in the Lower Gwynn's Falls area in the southwest quadrant of the intersection of Interstate 95 and the Baltimore-Washington Parkway. This tank would be in place of the 3.3 million gallon tank identified for the 5-year design storm. An 800,000 gallon storage tank would be required in the Upper Gwynn's Falls area near the western corner of the Carroll Park Golf Course. This tank would be in place of the 600,000 gallon tank identified for the 5-year design storm.

### 4.3 Option 2 – CIPP, West Interceptor Upsizing and Lower EAPS Water Level

Not a feasible option for this event.

### 4.4 Option 3 – CIPP with West Interceptor Upsizing

Not a feasible option for this event.

### 4.5 East Interceptor South of Patterson Park

The SSO problems in the area near the Eastern Interceptor south of Patterson Park identified for the 5-year design storm are increased accordingly to accommodate the larger design storm. The improvements listed below are in place of those for the 5-year design storm.

#### Option A: Storage and Minimal Upsizing

- Upsize 27-Inch Pipe to 36-Inch Pipe: To eliminate a hydraulic restriction along Glover Street to Patterson Park, approximately 1,275 feet of 27-inch pipe is proposed to be upsized to 36-inch pipe.



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- Upsize 27-Inch Pipe to 36-Inch Pipe: To eliminate a hydraulic restriction along Hudson Street, approximately 890 feet of 27-Inch pipe is proposed to be upsized to 36-Inch pipe. This upsize would occur between the intersection of Glover and Hudson Streets and the intersection of Port and Hudson Streets.
- Construct a Storage Facility: A 1.7 million gallon off line storage tank would be located along the harbor near the intersection of Lakewood Avenue and Boston Street. This tank would be in place of the 1.1 million gallon tank identified for the 5-year design storm.

### Option B: Extensive CIPP and Extensive Upsizing

- Upsize 27-Inch Pipe to 36-Inch Pipe: To eliminate a hydraulic restriction along Glover Street to Patterson Park, approximately 1,275 feet of 27-inch pipe is proposed to be upsized to 36-inch pipe.
- Upsize 48-Inch Pipe to 66-Inch Pipe: To eliminate a hydraulic restriction along the Eastern Interceptor from the intersection of Aliceanna Street and Wolfe Street to the intersection of Hudson Street and Boston Street approximately 2,310 feet of 48-Inch pipe is proposed to be upsized to 66-Inch pipe.
- Upsize 36-Inch Pipe to 54-Inch Pipe: To eliminate a hydraulic restriction along the Eastern Interceptor from the intersection of Hudson Street and Boston Street to the intersection of Boston Street and Linwood Avenue, approximately 2,550 feet of 36-Inch pipe is proposed to be upsized to 66-Inch pipe.

### 4.6 Locust Point Interceptor

The SSO problems in the vicinity of the Locust Point Interceptor identified for the 5-Year design storm event are increased accordingly to accommodate the larger design storm.

#### Option A: Storage and Minimal CIPP

- Construct a Storage Facility: A 500,000 gallon offline underground storage tank would be required in the upper Locust Point interceptor area. The underground storage tank would be located near the intersection of Key Highway and Fort Avenue. This storage tank would replace the 400,000 gallon tank identified for the 5-year design storm.
- CIPP All Sewer Pipes in 3 Additional Subcatchments. Three additional subcatchments in the vicinity of the Locust Point interceptor would have CIPP lining and manhole rehabilitation performed to reduce RDII flows from subcatchments

#### Option B: Upsize Pipes and Extensive CIPP

- Upsize 27 and 30-Inch Pipe to 48-Inch Pipe: To remove a hydraulic restriction that causes flooding in the upper portion of the Locust Point Interceptor is proposed to upsize approximately 1,600 feet of 27 and 30-Inch Pipe of Locust Interceptor to 48-Inch Pipe. The section to be upsized runs from between the intersections of East Key Highway and Woodall Street and Key Highway and Webster Street.
- CIPP All Sewer Pipes in 1 Additional Subcatchment. One additional subcatchment in the vicinity of the Locust Point interceptor would have CIPP lining and manhole rehabilitation performed to reduce RDII flows from the subcatchment.





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### 4.7 Western Gwynn's Falls

The SSO problems in the Western Gwynn's Falls area identified for the 5-year design storm are increased accordingly to accommodate the larger design storm. The improvements listed below are in place of those for the 5-year design storm.

#### Option A: Storage, Minimal CIPP, and Upsize Pipes

- Construct a 27-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 27-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 18-Inch parallel sewer identified in the 5-year design storm improvements.
- Construct a 21-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 310 feet of 21-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 18-Inch parallel sewer identified in the 5-year design storm improvements.
- Construct a Storage Facility: A 500,000 gallon offline underground storage tank would be required in the western side of Gwynn's Falls. The offline storage tank would be located near the intersection of Maisel Street and Carroll Street. This storage tank would replace the 300,000 gallon tank identified in the 5-year design storm improvements.

#### Option B: Extensive CIPP and Upsize Pipes

- Construct a 27-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 18-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 18-Inch parallel sewer identified in the 5-year design storm improvements.
- Construct a 21-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 310 feet of 21-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 18-Inch parallel sewer identified in the 5-year design storm improvements.
- Construct a 12-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 1,100 feet of 12-inch parallel sewer will be installed. This parallel sewer is located approximately between the intersections of Hollins Ferry Road and Severn Street and Laurey Street and Severn Street.

### 4.8 Summary of Estimated Costs

Table 4-1 and Table 4-2 summarize the estimated costs for the improvement options for the 10-year design storm. Option 1 is shown in green as being the recommended option. The recommended improvements are shown on Map 4.1.



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**Table 4-1: Summary of Estimated Costs for 10-Year Design Storm Improvements - Primary**

Improvement	Unit	Unit Cost	Option 1		Option 2		Option 3	
			Quantity	Total Cost	Quantity	Total Cost	Quantity	Total Cost
CIPP					NOT A VIABLE OPTION FOR THIS STORM EVENT		NOT A VIABLE OPTION FOR THIS STORM EVENT	
MH Rehab	Each	\$3,719	501	\$1,863,219				
<8-inches	LF	\$45	56,789	\$2,555,520				
9-12 inches	LF	\$64	11,133	\$712,535				
13-18 inches	LF	\$87	2,170	\$188,768				
19-24 inches	LF	\$124	674	\$83,526				
25-30 inches	LF	\$169	2,410	\$407,307				
31-36 inches	LF	\$186	1,076	\$200,138				
Pipe Replace								
New MH	Each	\$3,719	61	\$226,859				
<8-inches	LF	\$270	268	\$72,360				
9-12 inches	LF	\$495	4,559	\$2,256,705				
13-18 inches	LF	\$585	2,363	\$1,382,355				
25-30 inches	LF	\$1,440	2,281	\$3,284,640				
31-36 inches	LF	\$1,530	69	\$105,570				
Clean System	Tons	\$500	4,656	\$2,327,778				
Seal MH	Each	\$1,240	83	\$102,920				
Storage	Gallons	\$6	4,756,601	\$28,539,609				
Construction Costs				\$44,309,808				
Non-Construction Costs				\$18,610,119				
2008 TOTAL COSTS				\$62,919,927				



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**Table 4-2: Summary of Estimated Costs for 10-Year Design Storm Improvements - Localized Areas**

Item	Unit	Unit Cost	Western Gwynn's Falls Area				Eastern Interceptor Area				Locust Point Area			
			Storage		CIPP and Upsize		Storage		CIPP and Upsize		Storage		CIPP and Upsize	
			Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
CIPP														
MH Rehab <8-inches	Each	\$3,719	71	\$264,049	210	\$780,990	0	\$0	31	\$115,289	55	\$204,545	285	\$1,059,915
9-12 inches	LF	\$45	4,957	\$223,073	21,495	\$967,264	0	\$0	2,681	\$120,660	7,959	\$358,150	26,127	\$1,175,693
13-18 inches	LF	\$64	489	\$31,264	1,141	\$73,051	0	\$0	1,427	\$91,355	1,182	\$75,619	6,553	\$419,421
19-24 inches	LF	\$87	991	\$86,207	3,996	\$347,646	0	\$0	357	\$31,054	341	\$29,680	1,333	\$115,950
25-30 inches	LF	\$124	1,096	\$135,920	4,642	\$575,639	0	\$0	0	\$0	0	\$0	1,712	\$212,290
31-36 inches	LF	\$169	494	\$83,466	494	\$83,466	0	\$0	0	\$0	0	\$0	3,195	\$539,934
31-36 inches	LF	\$186	0	\$0	0	\$0	0	\$0	151	\$28,042	0	\$0	0	\$0
Replacement														
New MH	Each	\$3,719	13	\$48,347	20	\$74,380	10	\$37,190	33	\$122,727	0	\$0	8	\$29,752
9-12 inches	LF	\$495	726	\$359,370	1,097	\$543,015	0	\$0	0	\$0	0	\$0	0	\$0
13-18 inches	LF	\$585	19	\$11,115	19	\$11,115	0	\$0	0	\$0	0	\$0	0	\$0
19-24 inches	LF	\$1,080	308	\$332,640	308	\$332,640	0	\$0	996	\$1,075,680	0	\$0	0	\$0
25-30 inches	LF	\$1,440	733	\$1,055,520	733	\$1,055,520	0	\$0	0	\$0	0	\$0	0	\$0
31-36 inches	LF	\$1,530	0	\$0	0	\$0	2,276	\$3,482,280	2,276	\$3,482,280	0	\$0	0	\$0
49-54 inches	LF	\$1,800	0	\$0	0	\$0	0	\$0	2,547	\$4,584,600	0	\$0	1,570	\$2,826,000
>54 inches	LF	\$1,890	0	\$0	0	\$0	0	\$0	2,305	\$4,356,450	0	\$0	0	\$0
Storage	Gallons	\$6	452,360	\$2,714,161	0	\$0	1,695,008	\$10,170,048	0	\$0	428,814	\$2,572,884	0	\$0
Construction Costs				\$5,345,132		\$4,844,725		\$13,689,518		\$14,008,137		\$3,240,877		\$6,378,954
Non-Construction Costs				\$2,244,955		\$2,034,785		\$5,749,597		\$5,883,418		\$1,361,168		\$2,679,160
2008 TOTAL COSTS				\$7,590,087		\$6,879,510		\$19,439,115		\$19,891,555		\$4,602,046		\$9,058,114



## **Alternatives Analysis and Recommendations Report**

### **5.0 15-YEAR IMPROVEMENTS**

The 15-year design storm is anticipated to result in approximately 10.7 million gallons in SSOs throughout the Low Level Sewershed with flooding becoming more generalized throughout Low Level. The SSOs resulting from this storm are generally grouped in the Gwynn's Falls area, the East Interceptor area south of Patterson Park, the Locust Point Area, Western Gwynn's Falls, the north-central portion of the City just to the east of Interstate 83, the Washington Village area in the vicinity of Carroll Park, and the area to the west of DeSoto Park

As was the case with the 10-Year event, for the Gwynn's Falls area, Option 1 storage in upper and lower Gwynn's Falls becomes the only feasible alternative for eliminating the SSOs in that area. Options 2 and 3 become unfeasible due to the large diameter of pipe size required along the West Interceptor.

The SSO problems in the Eastern Interceptor area to the south of Patterson Park could be addressed by implementing same general alternatives presented for the 5-year and 10-year design storms. Both of the previous alternatives will need to be scaled up to account for the even larger design storm. The storage alternative has a lower cost than the CIPP/pipe upsizing option.

In the Locust Point Area, the same methodology presented in the 5-Year and 10-Year improvements was carried out for the 15-Year event. The extensive improvements required for the area pipe network result in the storage tank showing a substantially lower capital cost.

The Western Gwynn's Falls area, the same methodology presented in the 5-Year and 10-Year improvements was applied to the 15-Year event. The extensive improvements required in the area consist of either extensive CIPP and upsizing, or storage with upsizing and minimal CIPP. Cost analysis of these two options indicates that storage is the more cost effective method for eliminating SSOs in this area.

The Washington Village area in the vicinity of its main interceptor has seen many complaints regarding water-in-basement issues. Analysis of flow meter data in this area indicates an above average I&I influence. As-built drawings indicate the sanitary collection system in this area is nearly 100 years old further supporting the need of system rehabilitation in the form of CIPP and pipe upsizing.

The north-central portion of Low Level just east of Interstate 83 would continue to upsizing its interceptor sewer. The area to the west of DeSoto Park will be managed through subcatchment rehabilitation in addition to upsizing identified as part of the 5-year design storm improvements. The SSOs in the vicinity of the park could be addressed through upsizing additional pipes, but rehabilitation of the collection system in this area will provide an overall reduction in wet weather flows and will provide additional benefits for the collection system. The following improvements are in addition to those required for the 2-year, 5-year and 10-year design storm events except where noted. The recommended improvements are shown on Map 5.1.

#### **5.1 General Improvements (Apply to All Options)**

The general improvements for the 15-year storm event show the widespread SSO impacts this quantity of rainfall has on the Low Level Sewershed. As with the previous storm events, a large portion of these improvements are to address localized pipe diameter deficiencies that result in upstream overflows when the wastewater flows exceed the carrying capacity of the undersized pipe.



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- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction along Wicomico Street, approximately 470 feet of pipe would be upsized from 8-inch to 10-inch.
- Upsize 10-Inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction in the vicinity of Herkimer Street, approximately 400 feet of pipe would be upsized from 10-inch to 12-inch.
- Upsize 10-inch and 12-Inch Pipe to 15-Inch Pipe: To eliminate a hydraulic restriction along The Fallsway between the intersections of Madison and Monument Streets, approximately 360 feet of 10-inch and 12-Inch pipe is proposed to be upsized to 15-inch pipe to provide additional conveyance capacity.
- Upsize 15-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction between Paca Street and Ridgely Street, approximately 300 feet of 15-inch pipe is proposed to be upsized to 18-inch pipe to provide additional conveyance capacity.
- Upsize 18-Inch Pipe to 21-Inch Pipe: To eliminate a hydraulic restriction along South Carey Street between Washington Boulevard and Glyndon Avenue, approximately 520 feet of 18-inch pipe is proposed to be upsized to 21-inch pipe to provide additional conveyance capacity.
- Upsize 24-Inch Pipe to 27-Inch Pipe: To eliminate a hydraulic restriction along Ostend Street between Nanticoke Street and Hamburg Street, approximately 170 feet of 18-inch pipe is proposed to be upsized to 21-inch pipe to provide additional conveyance capacity.
- CIPP All Sewer Pipes in 4 Subcatchments: Three more subcatchments in the Gwynn's Falls area and one more subcatchment in the north-central area of Low Level would be subjected to an area-wide CIPP lining program.

### 5.2 Option 1 – Storage in Upper and Lower Gwynn's Falls

Two storage tanks in the Gwynn's Falls area capture excess flows during the 15-year design storm. In addition to the general improvements described previously, the following improvements are recommended for the 15-year design storm:

- Construct Two Storage Facilities: A 4.5 million gallon storage tank would be required in the Lower Gwynn's Falls area in the southwest quadrant of the intersection of Interstate 95 and the Baltimore-Washington Parkway. This tank would be in place of the 4.1 million gallon tank identified in the 10-year design storm improvements. A 1.0 million gallon storage tank would be required to be located in the Upper Gwynn's Falls area near the western corner of the Carroll Park Golf Course. This tank would be in place of the 800,000 gallon tank identified in the 10-year design storm improvements.

### 5.3 Option 2 – CIPP, West Interceptor Upsizing and Lower EAPS Water Level

Not a feasible option for this event.

### 5.4 Option 3 – CIPP with West Interceptor Upsizing

Not a feasible option for this event.

### 5.5 East Interceptor South of Patterson Park

The SSO problems in the area near the Eastern Interceptor south of Patterson Park identified for the 10-year design storm are increased accordingly to accommodate the larger design storm.





## Alternatives Analysis and Recommendations Report

### Option A: Storage and Minimal Upsizing

- Upsize 15-Inch and 18-Inch Pipe to 21-Inch Pipe: To eliminate a hydraulic restriction along Lakewood Avenue, approximately 1,000 feet of 18-inch pipe is proposed to be upsized to 21-inch pipe
- Construct a Storage Facility: A 1.9 million gallon off line storage tank would be located along the harbor near the intersection of Lakewood Avenue and Boston Street. This tank would be in place of the 1.7 million gallon tank identified in the 10-year design storm improvements.

### Option B: Extensive Upsizing and Extensive CIPP

- Upsize 48, 52, 55, and 60-Inch Pipe to 66-Inch Pipe: To eliminate hydraulic restrictions along Eastern Interceptor, approximately 1,900 feet of 48, 52, 55, and 60-inch pipe is proposed to be upsized to 66-inch pipe. This section of the East Interceptor runs along Aliceanna Street between the intersections of Caroline Street and Wolfe Street.
- Construct a 15-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction north of Patterson Park, approximately 2,400 feet of 15-inch parallel sewer is proposed to be constructed through Patterson Park. This parallel sewer will relieve the area just north of Patterson Park that has had a high number of basement flooding complaints.
- CIPP All Sewer Pipes in 2 Subcatchments. Two additional subcatchments in the Eastern Interceptor area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.

### 5.6 Locust Point Interceptor

The SSO problems in the vicinity of the Locust Point Interceptor identified for the 10-Year design storm event are increased accordingly to accommodate the larger design storm.

#### Option A: Storage, Minimal CIPP, and Upsizing

- Construct a Storage Facility: The storage tank is the same size as that identified for the 10-year design storm.
- Upsize 27 and 30-Inch Pipe to 48-Inch Pipe: To remove a hydraulic restriction that causes flooding in the upper portion of the Locust Point Interceptor, it is proposed to upsize approximately 1,200 feet of 27 and 30-Inch pipe of the Locust Point Interceptor to 48-Inch pipe. The section to be upsized runs from between the intersections of East Key Highway and Woodall Street and Key Highway and Boyle Street.
- CIPP All Sewer Pipes in 1 Subcatchment. One additional subcatchment in the Locust Point area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchment.

#### Option B: Extensive CIPP and Upsizing

- CIPP All Sewer Pipes in 1 Subcatchment. One additional subcatchment in the Locust Point area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchment.



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### 5.7 Western Gwynn's Falls

The SSO problems in the Western Gwynn's Falls area identified for the 10-year design storm are increased accordingly to accommodate the larger design storm.

#### Option A: Storage, Minimal CIPP, and Upsizing

- Construct a Storage Facility: A 600,000 gallon offline underground storage tank would be located near the intersection of Maisel Street and Carroll Street. This storage tank would replace the 500,000 gallon tank identified in the 10-year design storm improvements.
- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction in the vicinity of the intersection of Raymond Street and Carroll Street, approximately 710 feet of 8-Inch pipe is proposed to be upsized to 10-Inch pipe

#### Option B: Extensive CIPP and Upsizing

- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction in the vicinity of the intersection of Raymond Street and Carroll Street, approximately 710 feet of 8-Inch pipe is proposed to be upsized to 10-Inch pipe
- Upsize 10-Inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction along Hollins Ferry Road, approximately 300 feet of 10-Inch pipe is proposed to be upsized to 12-Inch pipe.
- Upsize 15-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction along Grove Street and its intersection with Spence Street, approximately 380 feet of 15-Inch pipe is proposed to be upsized to 18-Inch pipe.

### 5.8 Summary of Estimated Costs

Table 5-1 and Table 5-2 summarize the estimated costs for the improvement options for the 15-year design storm. Option 1 is shown in green as being the recommended option. The recommended improvements are shown on Map 5.1.



## Alternatives Analysis and Recommendations Report

**Table 5-1: Summary of Estimated Costs for 15-Year Design Storm Improvements - Primary**

Improvement	Unit	Unit Cost	Option 1		Option 2		Option 3	
			Quantity	Total Cost	Quantity	Total Cost	Quantity	Total Cost
CIPP					NOT A VIABLE OPTION FOR THIS STORM EVENT		NOT A VIABLE OPTION FOR THIS STORM EVENT	
MH Rehab	Each	\$3,719	554	\$2,060,326				
<8-inches	LF	\$45	62,004	\$2,790,193				
9-12 inches	LF	\$64	11,626	\$744,071				
13-18 inches	LF	\$87	3,029	\$263,514				
19-24 inches	LF	\$124	511	\$63,314				
25-30 inches	LF	\$169	2,410	\$407,307				
31-36 inches	LF	\$186	1,076	\$200,138				
Replacement								
New MH	Each	\$3,719	81	\$301,239				
<8-inches	LF	\$270	268	\$72,360				
9-12 inches	LF	\$495	5,427	\$2,686,365				
13-18 inches	LF	\$585	3,004	\$1,757,340				
19-24 inches	LF	\$1,080	505	\$545,400				
25-30 inches	LF	\$1,440	2,444	\$3,519,360				
31-36 inches	LF	\$1,530	69	\$105,570				
Clean System	Tons	\$500	4,656	\$2,327,778				
Seal MH	Each	\$1,240	83	\$102,920				
Storage	Gallons	\$6	5,451,054	\$32,706,322				
Construction Costs				\$50,653,517				
Non-Construction Costs				\$21,274,477				
2008 TOTAL COSTS				\$71,927,994				



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**Table 5-2: Summary of Estimated Costs for 15-Year Design Storm Improvements - Localized Areas**

Item	Unit	Unit Cost	Western Gwynn's Falls Area				Eastern Interceptor Area				Locust Point Area			
			Storage		CIPP and Upsize		Storage		CIPP and Upsize		Storage		CIPP and Upsize	
			Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
CIPP														
MH Rehab	Each	\$3,719	71	\$264,049	210	\$780,990	0	\$0	39	\$145,041	62	\$230,578	292	\$1,085,948
<8-inches	LF	\$45	4,957	\$223,073	21,495	\$967,264	0	\$0	2,681	\$120,660	8,675	\$390,362	27,210	\$1,224,452
9-12 inches	LF	\$64	489	\$31,264	1,141	\$73,051	0	\$0	2,126	\$136,083	2,412	\$154,372	8,222	\$526,185
13-18 inches	LF	\$87	991	\$86,207	3,996	\$347,646	0	\$0	357	\$31,054	341	\$29,680	1,333	\$115,950
19-24 inches	LF	\$124	1,096	\$135,920	4,642	\$575,639	0	\$0	0	\$0	0	\$0	1,712	\$212,290
25-30 inches	LF	\$169	494	\$83,466	494	\$83,466	0	\$0	0	\$0	0	\$0	3,195	\$539,934
31-36 inches	LF	\$186	0	\$0	0	\$0	0	\$0	151	\$28,042	0	\$0	0	\$0
Replacement														
New MH	Each	\$3,719	20	\$74,380	30	\$111,570	16	\$59,504	54	\$200,826	6	\$22,314	8	\$29,752
<8-inches	LF	\$270	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0
9-12 inches	LF	\$495	1,434	\$709,830	2,095	\$1,037,025	0	\$0	0	\$0	96	\$47,520	0	\$0
13-18 inches	LF	\$585	19	\$11,115	390	\$228,150	0	\$0	2,375	\$1,389,375	0	\$0	0	\$0
19-24 inches	LF	\$1,080	308	\$332,640	308	\$332,640	996	\$1,075,680	996	\$1,075,680	0	\$0	0	\$0
25-30 inches	LF	\$1,440	733	\$1,055,520	733	\$1,055,520	0	\$0	0	\$0	0	\$0	0	\$0
31-36 inches	LF	\$1,530	0	\$0	0	\$0	2,276	\$3,482,280	2,276	\$3,482,280	0	\$0	0	\$0
43-48-inches	LF	\$1,710	0	\$0	0	\$0	0	\$0	0	\$0	1,121	\$1,916,910	0	\$0
49-54 inches	LF	\$1,800	0	\$0	0	\$0	0	\$0	2,547	\$4,584,600	0	\$0	1,570	\$2,826,000
>54 inches	LF	\$1,890	0	\$0	0	\$0	0	\$0	4,168	\$7,877,520	0	\$0	0	\$0
Storage	Gallons	\$6	576,254	\$3,457,525	0	\$0	1,800,177	\$10,801,062	0	\$0	433,879	\$2,603,277	0	\$0
Construction Costs				\$6,464,988		\$5,592,960		\$15,418,526		\$19,071,161		\$5,395,014		\$6,560,510
Non-Construction Costs				\$2,715,295		\$2,349,043		\$6,475,781		\$8,009,887		\$2,265,906		\$2,755,414
2008 TOTAL COSTS				\$9,180,283		\$7,942,003		\$21,894,307		\$27,081,048		\$7,660,919		\$9,315,924



## Alternatives Analysis and Recommendations Report

### 6.0 20-YEAR IMPROVEMENTS

The 20-year design storm is anticipated to result in approximately 12.3 million gallons in SSOs throughout the Low Level Sewershed with additional groupings of SSOs becoming more apparent than for the smaller design storms. The SSOs resulting from this storm are generally grouped in the Gwynn's Falls area, the Eastern Interceptor area south of Patterson Park, the Locust Point area, Western Gwynn's Falls, the north-central portion of the City just to the east of Interstate 83, the Washington Village area in the vicinity of Carroll Park, and the area to the west of DeSoto Park.

As was the case with the 10-year and 15-year design storms for the Gwynn's Falls area, storage in upper and lower Gwynn's Falls (Option 1) is the only feasible alternative for eliminating the SSOs.

For the Eastern Interceptor area south of Patterson Park, and West Gwynn's Falls area, the same methodology used for the 5-year, 10-year, and 15-year design storms was used for the 20-year design storm. Expanding the extents of the CIPP and pipe upsizing or use of a larger storage tank with minimal pipe upsizing are two possible solutions. Cost comparison of these two options indicates that storage is the more cost effective method for eliminating SSOs in both areas.

In the Locust Point area, the same methodology used for the 5-year, 10-year and 15-year design storms was used for the 20-year design storm. Storage was the only feasible option for this design storm and continues the trend of storage being significantly lower cost than CIPP/pipe upsizing.

The Washington Village area and the north-central portion of the City just east of Interstate 83 would continue with their respective rehabilitation efforts as outlined in previous storm events.

The following improvements, in addition to those required for the 2-year, 5-year, 10-year and 15-year design storms except where noted. The recommended improvements are shown on Map 6.1.

#### 6.1 General Improvements (Apply to All Options)

The general improvements for the 20-year design storm reveal the increasingly widespread SSO impacts this large and intense design storm has on Low Level. A majority of these improvements are to address localized SSO conditions resulting from undersized pipes, excessive I&I or downstream capacity constraints. The general improvements for this design storm are:

- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction near the intersection of Monroe Street and Eagle Street, approximately 200 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe to provide additional conveyance capacity.
- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction along Hudson Street and the intersections of Potomac Street, Decker Street, and Linwood Street approximately 270 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe to provide additional conveyance capacity
- Upsize 8-Inch Pipe to 10-Inch Pipe: To eliminate a hydraulic restriction near the intersection of Christian Street and Catherine Street, approximately 200 feet of 8-inch pipe is proposed to be upsized to 10-inch pipe to provide additional conveyance capacity
- Upsize 10-inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction along Wicomico Street approximately 210 feet of 10-Inch pipe is proposed to be upsized to 12-Inch pipe.



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- Upsize 10-Inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction in the vicinity of Herkimer Street, approximately 500 feet of pipe would be upsized from 10-inch to 12-inch.
- Construct 12-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction between the intersections of Ellwood and Linwood Streets, a 12-inch parallel sewer will be installed. Seven manholes will be installed as part of this improvement. This parallel sewer will replace the 10-Inch parallel sewer proposed in the 2-year design storm improvements.
- Upsize 15-Inch Pipe to 21-Inch Pipe: To eliminate a hydraulic restriction between Paca Street and Ridgely Street, approximately 300 feet of 15-inch pipe is proposed to be upsized to 21-inch pipe to provide additional conveyance capacity. This upsize will replace the 18-Inch pipe upsize proposed in the 15-year design storm improvements.
- Upsize 18-Inch Pipe to 24-Inch Pipe: Along Wilkens Avenue near the intersection of Wilmington Avenue, approximately 1,000 feet of 18-inch pipe are recommended to be upsized to 24-inches to provide additional conveyance capacity for the area.
- CIPP All Sewer Pipes in 4 Subcatchments: Four more subcatchments in the Washington Hills section of the City would have CIPP lining and manhole rehabilitation performed to reduce RDII flows from these subcatchments.

### 6.2 Option 1 – Storage in Upper and Lower Gwynn’s Falls

Two storage tanks in the Gwynn’s Falls area provide the needed volume to contain the excess wastewater flows during the 20-year design storm event as described below:

- Construct Two Storage Facilities: A 4.9 million gallon storage tank would be required in the Lower Gwynn’s Falls area in the southwest quadrant of the intersection of Interstate 95 and the Baltimore-Washington Parkway. This tank would be in place of the 4.5 million gallon tank identified in the 15-year design storm improvements. A 1.1 million gallon storage tank would be required to be located in the Upper Gwynn’s Falls area near the western corner of the Carroll Park Golf Course. This tank would be in place of the 1.0 million gallon tank identified in the 15-year design storm improvements.

### 6.3 Option 2 – CIPP, West Interceptor Upsizing and Lower EAPS Water Level

Not a feasible option for this storm event.

### 6.4 Option 3 – CIPP with West Interceptor Upsizing

Not a feasible option for this storm event.

### 6.5 East Interceptor South of Patterson Park

The SSO problems in the area near the Eastern Interceptor south of Patterson Park identified for the 15-year design storm are increased accordingly to accommodate the larger design storm.

#### Option A: Storage, Minimal Upsizing, and CIPP

- Construct a 12-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction north of Patterson Park, approximately 2,400 feet of 12-inch parallel sewer is proposed to be constructed through Patterson Park. This parallel sewer will relieve the area just north of Patterson Park that has had a high number of basement flooding complaints.





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- Upsize 10-inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction along Hudson Street between the intersections of Lakewood and Belnord Streets, approximately 80 feet of 10-Inch pipe is proposed to be upsized to 12-Inch pipe.
- Upsize 36-inch Pipe to 42-Inch Pipe: To eliminate a hydraulic restriction in the upper reaches of the Eastern Interceptor along Boston Street between the intersections of East and Highland Avenues, approximately 700 feet of 36-Inch pipe is proposed to be upsized to 42-Inch to provide additional hydraulic conveyance.
- CIPP All Sewer Pipes in 2 Subcatchments Two additional subcatchments in the Eastern Interceptor area would have CIPP lining and manhole rehabilitation performed to reduce RDII flow from the subcatchments.
- Construct a Storage Facility: A 2.1 million gallon off line storage tank would be located along the harbor near the intersection of Lakewood Avenue and Boston Street. This tank would be in place of the 1.9 million gallon tank identified in the 15-year design storm improvements.

### Option B: Extensive Upsizing and CIPP

- Upsize 10-inch Pipe to 12-Inch Pipe: To eliminate a hydraulic restriction along Hudson Street between the intersections of Lakewood and Belnord Streets, approximately 80 feet of 10-Inch pipe is proposed to be upsized to 12-Inch pipe.
- Construct a 18-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction north of Patterson Park, approximately 2,400 feet of 18-inch parallel sewer is proposed to be constructed through Patterson Park. This parallel sewer will replace the 15-Inch parallel sewer identified in the 15-year design storm improvements.
- Upsize 36-inch Pipe to 42-Inch Pipe: To eliminate a hydraulic restriction in the upper reaches of the Eastern Interceptor along Boston Street between the intersection of Linwood Avenue and Highland Avenue, approximately 2,000 feet of 36-Inch pipe is proposed to be upsized to 42-Inch to provide additional hydraulic conveyance.
- Upsize 36 and 48-Inch Pipe to 66-Inch Pipe: To eliminate a hydraulic restriction in the Eastern Interceptor along Boston Street between the intersection of Hudson Street and Binney Street, approximately 1,700 feet of 36 and 48-Inch pipe is proposed to be upsized to 66-Inch to provide additional hydraulic conveyance.

### 6.6 Locust Point Interceptor

The SSO problems in the vicinity of the Locust Point Interceptor identified for the 15-Year design storm event are increased accordingly to accommodate the larger design storm.

#### Option A: Store, Upsizing, and Minimal Upsizing

- Upsize 27 and 30-Inch Pipe to 52-Inch Pipe: To remove a hydraulic restriction that causes flooding in the upper portion of the Locust Point interceptor it is proposed to upsize approximately 2,300 feet of 27 and 30-Inch pipe of the Locust Point Interceptor to 52-Inch pipe. The upsized section runs from between the intersections of East Key Highway and past Woodall Street and Key Highway and Webster Street.
- Upsize 8-Inch Pipe to 10-Inch Pipe: To remove a hydraulic restriction at the intersection of Webster and Walls Street it is proposed to upsize approximately 100 feet of 8-Inch pipe to 10-Inch pipe.



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### Option B: Extensive CIPP and Extensive Upsizing

This option is not feasible due to the need to upsize the entire Locust Point Interceptor to the connection with the Western Interceptor. The hydraulic grade line at the junction point of the Locust and Western Interceptors is high enough for this option to be eliminated from consideration in addition to this option having much higher costs than storage.

### 6.7 Western Gwynn's Falls

The SSO problems in the Western Gwynn's Falls area identified for the 15-year design storm are increased accordingly to accommodate the larger design storm.

#### Option A: Storage, Minimal CIPP, and Upsizing

- Upsize 15-Inch Pipe to 18-Inch Pipe: To eliminate a hydraulic restriction along Grove Street and its intersection with Spence Street, approximately 380 feet of 15-Inch pipe is proposed to be upsized to 18-Inch pipe.
- Construct a 36-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 36-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 27-Inch parallel sewer identified in the 10-year design storm improvements.
- Construct a 36-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 310 feet of 21-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 21-Inch parallel sewer identified in the 10-year design storm improvements.
- Construct a Storage Facility: A 600,000 gallon offline underground storage tank would be located near the intersection of Maisel Street and Carroll Street. This storage tank would replace the 500,000 gallon tank identified in the 10-year design storm improvements.

#### Option B: Extensive Upsizing and Extensive CIPP

- Upsize 18-Inch Pipe to 24-Inch Pipe: To eliminate a hydraulic restriction along the northern interceptor just north of the siphon, approximately 1,900 feet of 24-Inch pipe is proposed to be upsized to 30-Inch pipe. This section of pipe is approximately between the intersection of Herkimer Street and Monterey Street and the intersection of Maisel Street and Bremen Street.
- Upsize 24-Inch Pipe to 30-Inch Pipe: To eliminate a hydraulic restriction along the northern interceptor just north of the siphon, approximately 1,700 feet of 24-Inch pipe is proposed to be upsized to 30-Inch pipe.
- Construct a 36-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 740 feet of 36-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 27-Inch parallel sewer identified in the 10-year design storm improvements.
- Construct a 36-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 310 feet of 21-inch parallel sewer will be installed. Six manholes will be installed as part of this improvement. This parallel sewer would replace the 21-Inch parallel sewer identified in the 10-year design storm improvements.
- Construct a 15-Inch Wet Weather Parallel Sewer: To eliminate a hydraulic restriction just southwest of the siphon, approximately 1,100 feet of 12-inch parallel sewer will be installed.



## Alternatives Analysis and Recommendations Report

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This parallel sewer is located along Severn Street between the intersection of Hollins Ferry Road and Laurey Street. The 15-Inch parallel sewer would replace the 12-Inch parallel sewer identified in the 10-year design storm improvements.

### 6.8 Summary of Estimated Costs

Table 6-1 and Table 6-2 summarize the estimated costs for the improvement options for the 20-year design storm. Option 1 is shown in green as being the recommended option. The recommended improvements are shown on Map 5.1.



## Alternatives Analysis and Recommendations Report

**Table 6-1: Summary of Estimated Costs for 20-Year Design Storm Improvements - Primary**

Improvement	Unit	Unit Cost	Option 1		Option 2		Option 3	
			Qty.	Total Cost	Qty.	Total Cost	Qty.	Total Cost
CIPP					NOT A VIABLE OPTION FOR THIS STORM EVENT		NOT A VIABLE OPTION FOR THIS STORM EVENT	
MH Rehab	Each	\$3,719	658	\$2,447,102				
<8-inches	LF	\$45	78,323	\$3,524,535				
9-12 inches	LF	\$64	12,336	\$789,516				
13-18 inches	LF	\$87	2,947	\$256,393				
19-24 inches	LF	\$124	1,724	\$213,749				
25-30 inches	LF	\$169	2,375	\$401,385				
31-36 inches	LF	\$186	1,076	\$200,138				
Replacement								
New MH	Each	\$3,719	101	\$375,619				
<8-inches	LF	\$270	268	\$72,360				
9-12 inches	LF	\$495	6,735	\$3,333,825				
13-18 inches	LF	\$585	2,939	\$1,719,315				
19-24 inches	LF	\$1,080	1,787	\$1,929,960				
25-30 inches	LF	\$1,440	2,444	\$3,519,360				
31-36 inches	LF	\$1,530	69	\$105,570				
37-42 inches	LF	\$1,620	31	\$50,220				
Clean System	Tons	\$500	4,656	\$2,327,778				
Seal MH	Each	\$1,240	83	\$102,920				
Storage	Gallons	\$6	6,098,977	\$36,593,864				
Construction Costs				\$57,963,609				
Non-Construction Costs				\$24,344,716				
2008 TOTAL COSTS				\$82,308,325				



## Alternatives Analysis and Recommendations Report

**Table 6-2: Summary of Estimated Costs for 20-Year Design Storm Improvements - Localized Areas**

Item	Unit	Unit Cost	Western Gwynn's Falls Area				Eastern Interceptor Area				Locust Point Area				
			Storage		CIPP and Upsize		Storage		CIPP and Upsize		Storage		CIPP and Upsize		
			Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost	
CIPP															NOT A VIABLE OPTION FOR THIS STORM EVENT
MH Rehab	Each	\$3,719	71	\$264,049	177	\$658,263	8	\$29,752	39	\$145,041	62	\$230,578			
<8-inches	LF	\$45	4,957	\$223,073	21,495	\$967,264	0	\$0	2,681	\$120,660	8,675	\$390,362			
9-12 inches	LF	\$64	489	\$31,264	1,141	\$73,051	699	\$44,736	2,126	\$136,083	2,412	\$154,372			
13-18 inches	LF	\$87	991	\$86,207	2,347	\$204,183	0	\$0	357	\$31,054	341	\$29,680			
19-24 inches	LF	\$124	1,096	\$135,920	3,008	\$373,023	0	\$0	0	\$0	0	\$0			
25-30 inches	LF	\$169	494	\$83,466	494	\$83,466	0	\$0	0	\$0	0	\$0			
31-36 inches	LF	\$186	0	\$0	0	\$0	0	\$0	151	\$28,042	0	\$0			
Replacement															
New MH	Each	\$3,719	24	\$89,256	44	\$163,636	35	\$130,165	61	\$226,859	12	\$44,628			
<8-inches	LF	\$270	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0			
9-12 inches	LF	\$495	1,434	\$709,830	998	\$494,010	2,450	\$1,212,750	0	\$0	0	\$0			
13-18 inches	LF	\$585	390	\$228,150	1,486	\$869,310	0	\$0	2,276	\$1,331,460	0	\$0			
19-24 inches	LF	\$1,080	0	\$0	1,845	\$1,992,600	996	\$1,075,680	996	\$1,075,680	0	\$0			
25-30 inches	LF	\$1,440	0	\$0	1,635	\$2,354,400	0	\$0	0	\$0	0	\$0			
31-36 inches	LF	\$1,530	1,041	\$1,592,730	1,041	\$1,592,730	2,686	\$4,109,580	2,276	\$3,482,280	0	\$0			
37-42 inches	LF	\$1,620	0	\$0	0	\$0	698	\$1,130,760	1,951	\$3,160,620	0	\$0			
49-54 inches	LF	\$1,800	0	\$0	0	\$0	0	\$0	888	\$1,598,400	1,121	\$2,017,800			
>54 inches	LF	\$1,890	0	\$0	0	\$0	0	\$0	5,827	\$11,013,030	0	\$0			
Storage	Gallons	\$6	684,640	\$4,107,842	0	\$0	2,053,305	\$12,319,832	0	\$0	462,848	\$2,777,091			
Construction Costs				\$7,551,787		\$9,825,935		\$20,053,255		\$22,349,209		\$5,644,511			
Non-Construction Costs				\$3,171,751		\$4,126,893		\$8,422,367		\$9,386,668		\$2,370,695			
2008 TOTAL COSTS				\$10,723,538		\$13,952,828		\$28,475,622		\$31,735,876		\$8,015,206			

**Alternatives Analysis and Recommendations Report****7.0 SUMMARY**

Based on review of all of the alternatives discussed in this report and their capital costs, a recommendation for system improvements was made. Table 7-1 provides a summary of estimated costs for a combination of all the recommended alternatives for the 20-year design storm. The storage options generally proved less expensive than a combination of CIPP and pipe upsizing in most cases. This combination of improvements will be used for the following cost analyses.

**Table 7-1: Total Estimated Low Level Recommended Improvement Costs for 20-Year Design Storm**

Improvement	Unit	Unit Cost	Recommendations	
			Qty.	Cost
CIPP				
MH Rehab	Each	\$3,719	799	\$2,971,481
<8-inches	LF	\$45	91,955	\$4,137,971
9-12 inches	LF	\$64	15,936	\$1,019,888
13-18 inches	LF	\$87	4,279	\$372,280
19-24 inches	LF	\$124	2,820	\$349,668
25-30 inches	LF	\$169	2,869	\$484,851
31-36 inches	LF	\$186	1,076	\$200,138
Replacement				
New MH	Each	\$3,719	172	\$639,668
<8-inches	LF	\$270	268	\$72,360
9-12 inches	LF	\$495	10,619	\$5,256,405
13-18 inches	LF	\$585	3,329	\$1,947,465
19-24 inches	LF	\$1,080	2,783	\$3,005,640
25-30 inches	LF	\$1,440	2,444	\$3,519,360
31-36 inches	LF	\$1,530	3,796	\$5,807,880
37-42 inches	LF	\$1,620	729	\$1,180,980
49-54 inches	LF	\$1,800	1,121	\$2,017,800
Clean System	Tons	\$500	4,656	\$2,327,778
Seal MH	Each	\$1,240	83	\$102,920
Storage	Gallons	\$6	9,299,771	\$55,798,629
Construction Costs				\$91,213,162
Non-Construction Costs				\$38,309,528
2008 TOTAL COSTS				\$129,522,690





## Alternatives Analysis and Recommendations Report

The total improvement costs for the recommended improvement scenarios are presented in Table 7-2. The table shows the increase in cost with larger design storm and the cost increase over time due to inflation. Table 7-3 shows a similar table at all costs on a cost per gallon of SSO removed basis.

**Table 7-2: Total Estimated Low Level Improvement Costs (million dollars)**

Projected Year	2 Year	5 Year		10 Year		15 Year		20 Year	
		Add	Total	Add	Total	Add	Total	Add	Total
2008	\$28.9	\$31.0	\$59.9	\$33.9	\$93.8	\$15.6	\$109.4	\$20.1	\$129.5
2009	\$30.9	\$33.1	\$64.1	\$36.3	\$100.4	\$16.7	\$117.1	\$21.5	\$138.6
2010	\$33.1	\$35.5	\$68.6	\$38.9	\$107.4	\$17.8	\$125.3	\$23.0	\$148.3
2011	\$35.4	\$37.9	\$73.4	\$41.6	\$114.9	\$19.1	\$134.0	\$24.6	\$158.7
2012	\$37.9	\$40.6	\$78.5	\$44.5	\$123.0	\$20.4	\$143.4	\$26.3	\$169.8
2013	\$40.6	\$43.4	\$84.0	\$47.6	\$131.6	\$21.9	\$153.5	\$28.2	\$181.6
2014	\$43.4	\$46.5	\$89.9	\$50.9	\$140.8	\$23.4	\$164.2	\$30.2	\$194.4
2015	\$46.4	\$49.7	\$96.2	\$54.5	\$150.7	\$25.0	\$175.7	\$32.3	\$208.0
2016	\$49.7	\$53.2	\$102.9	\$58.3	\$161.2	\$26.8	\$188.0	\$34.5	\$222.5
2017	\$53.2	\$56.9	\$110.1	\$62.4	\$172.5	\$28.7	\$201.2	\$36.9	\$238.1

**Table 7-3: Estimated Low Level Improvement Costs Per Gallon SSO Removed**

Projected Year	2 Year	5 Year		10 Year		15 Year		20 Year	
		Add	Total	Add	Total	Add	Total	Add	Total
SSO Volume (MG)	3.46	2.83	6.29	2.74	9.03	1.58	10.61	1.80	12.41
2008	\$8.35	\$10.96	\$9.52	\$12.41	\$10.40	\$9.86	\$10.32	\$11.15	\$10.44
2009	\$8.93	\$11.72	\$10.19	\$13.28	\$11.12	\$10.55	\$11.04	\$11.93	\$11.17
2010	\$9.56	\$12.55	\$10.90	\$14.21	\$11.90	\$11.29	\$11.81	\$12.76	\$11.95
2011	\$10.23	\$13.42	\$11.66	\$15.20	\$12.74	\$12.08	\$12.64	\$13.66	\$12.79
2012	\$10.94	\$14.36	\$12.48	\$16.27	\$13.63	\$12.93	\$13.52	\$14.61	\$13.68
2013	\$11.71	\$15.37	\$13.35	\$17.41	\$14.58	\$13.83	\$14.47	\$15.64	\$14.64
2014	\$12.53	\$16.44	\$14.29	\$18.63	\$15.60	\$14.80	\$15.48	\$16.73	\$15.66
2015	\$13.41	\$17.60	\$15.29	\$19.93	\$16.70	\$15.84	\$16.57	\$17.90	\$16.76
2016	\$14.35	\$18.83	\$16.36	\$21.32	\$17.86	\$16.95	\$17.73	\$19.15	\$17.93
2017	\$15.35	\$20.14	\$17.50	\$22.82	\$19.11	\$18.13	\$18.97	\$20.49	\$19.19